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SELECTED TRANSLATIONS ON SOVIET MEDICAL RADIOLOGY AND RADIATION

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SELECTED TRANSLATIONS ON SOVIET MEDICAL RADIOLOGY AND RADIATION

This report contains two translations on medical radiology and radiation taken from the periodical Sovetskaya meditsina (Soviet Medicine), No 9, Moscow, September 1960. The titles of the articles are given below in the table of contents.

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THE PRESENT STAGE OF MEDICAL RADIOLOGY*

-USSR-

[Following is the translation of an article by Prof I. G. Lagunova (Moscow), Director of the State Scientific-Research Roentgeno-Radiological Institute of the Ministry of Public Health RSFSR, in Sovetskaya meditsina (Soviet Medicine), No 9, Moscow, September 1960, pages 26-31.]

The brilliant achievements in the field of nuclear physics, the discovery of the structure of the atom and the control of atomic energy gave mankind not only boundless sources of energy but also new and powerful means of studying the extremely complicated processes which take place in the animal and plant kingdoms and which cannot be studied by any other methods.

Besides the naturally radioactive substances, it is now possible to induce artificial radioactivity in almost all the chemicals of Mendeleev's table. This gives the researchers a wide choice of sources of radiations.

From the beginning of the discovery of radioactivity, radioactive substances began to assume a distinctive meaning in medicine. A new branch of medical science and practice, medical radiology, began to come into existence. The development of medical radiology can be divided into several periods.

The first period, the period during which medical radiology was in the process of becoming an independent discipline, began with the very discovery of the phenomenon of radioactivity and its effects on biological matter. It is characterized by the empirical study of this biological effect, and by the use of naturally radioactive material for medical purposes.

In the second period, which began in 1945-1946, medical radiology underwent vigorous growth. This

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* Presented at the Tashkent Conference on the Peaceful Uses of Atomic Energy, Tashkent, September, 1959.

period was characterized by the widespread study of artificial radioactive substances and the selection from them of the most useful ones for the pruposes of scientific research and clinical application; by experimental study of biological effects of radiological energy, the working out of numerous methods of diagnosis and clinical application of radioactive isotopes, and finally, the development of radiological equipment.

The last and current period, which began in 1955-1956, is a period of relative stabilization, a period of unique "reevaluation of standards" together with the analysis and synthesis of all previously collected data. It is a period of sober comparative evaluation and comparison of isolated results of the uses of the different radioactive matters and the various techniques for using them.

During the period of vigorous development of medical radiology, we can discern three tendencies. The first of these is characterized by the use of radioactive isotopes for research on the different life processes (biochemical and physiological) of a live human organism which are inaccessible or not easily accessible to research by other methods.

After it became apparent that it is possible to introduce radioactive matters into all kinds of organic and inorganic compounds, to "labls" the proteins, vitaminds, hormones, bacteria, medicinal matters, etc., both we here and those abroad began an intensive study of metabolism, distribution, speed of conversion, movement and extraction from the organism of the matter introduced into it. Studies were begun on the functions of various organs and systems of the living human being both in his normal and pathological states. To study the metabolism of the bones, there were experiments with the use of radioactive phosphorus, calcium, gallium and strontium. To study the processes of the formation and circulation of the blood they use radioactive iron, sodium, potassium and rubidium, and finally, to study functions of the thyroid gland and others, they used radioactive iodine. These studies allowed at this time the formulation of definite methods and the definition of a number of radioactive matters which can have wide practical application. However, there is much to be explored in this field.

The second tendency is characterized by the application of radioactive substances in clinical diagnostics. It is also based on the study of the distribution of introduced radioactive matter, the speed of its movement and the intensity of allocation in the dif-

ferent tissues, organs and systems of the organism. The radioactive substance, being a source of radiation, can be detected at a distance by special counting devices. In some ways this tendency is similar to the first, especially when we use this method to study the functions of organs and systems; the purpose is, however, different for it is purely clinical.

At first this method (the method of using radioactive indicators) seemed very promising. The research proceeded in three directions: 1) the utilisation of organotropic and tumorotropic properties of radioactive matter; 2) the choice of the most effective indicators from the point of view of the relationship of safe dosages and the fruitfulness of research; and, 3) the development and perfection of counters. However, not all hopes were fulfilled. Organotropic and tumorotropic properties of radioactive substances turned out to be somewhat restricted and relative. Numerous experiments showed that the introduction of any radioactive matter into the organism caused definite shifts in the functions of the different organs and systems, especially in the central nervous system and the organs of blood formation. Therefore, in clinical usage the method of using indicators must be restricted by very careful directives.

At the present time the most practical application of the indicative method in clinical practice is the use of radioactive iodine. Through it, it is possible to diagnose the diseases of the thyroid gland and the changes in its function caused by the disfunctioning of other organs.

The other method which received some practical application is the use of radioactive sodium, iron and iodine to determine the velocity of general and capillary blood circulation. And it must be added that the velocity of the blood-flow can be studied not only in the whole cardio-vascular system, but also in isolated regions; for example in the pulmonary circle, in the blood vessels of the brain, in the blood vessels of any extremity, in the transplanted layer of skin, or locally in the regions of any lesion. The study of hemodynamics has a great practical value especially in the therapeutic and general clinics.

By means of the introduction of radioactive phosphorus, we can also determine the volume of the circulating blood, and with radioactive iron, the content of hemoglobin in the erythrocytes.

The diagnosis of tumors by means of radioactive indicators is limited in practice to the topical

diagnosis of tumors of the thyroid gland by radioactive iodine and the diagnosis of cerebral tumors by means of radioactive phosphorus or isotopes of arsenic which radiate positrons.

While on the topic of diagnostics, we should also mention an attempt to create an apparatus of a radiograph or gammagraph with radioactive isotopes (analogous to the X-ray machine) primarily for the study of the bone structure. Radioactive thulium and xenon were used for this. However, as the research at our institute shows, regardless of the necessary compactness and simplicity of the machine, radiography cannot be realized in practice at present with the use of conventional protective substances. It is possible that in the future, with the development of highly sensitive film, with the improved photographic screens, electronic optical transformers, and other technological improvements, this method also will find its place in the clinic.

The third tendency is characterized by the use of radioactivity for curing purposes. This widest and most heuristic branch won over almost all other branches of medicine. The production of long-lived radioactive isotopes of cobalt whose radiation in its physical and biological properties is similar to that of radium and the creation of a powerful gamma apparatus made possible the improvement of the methods of curing and also their practical application in the hospitals. The radioactive phosphorus which is the source of the homogeneous beta-rays and radioactive gold in colloidal state gave a push in the development of the new methods of beta-therapy. During the whole period of the development of radiology, the branch of medicine concerned with curing was studying different radioactive isotopes and developing new methods of therapy. Thus, both we and the scientists abroad conducted research to determine the useability of radioactive strontium for external ray therapy especially for some diseases of the eye. We worked as well on the utility of tantalium in interstitial therapy, and on the solutions of radioactive sodium and lutetium in the intra-tumoral therapy. We investigated the use of radioactive copper for the cure of melanoms, and radioactive gallium for curing the tumors of the bones. As a result of these and other numerous studies, the assortment of radioactive isotopes used in medical therapy is almost stabilized at the present time. In general it is limited to radioactive cobalt, phosphorus, iodine and gold.

All the developed methods of curing which have achieved practical application can be divided into four

basic groups: 1) external radiation; 2) intracavitary radiation; 3) interstitial radiation; and, 4) internal radiation. All these are methods of curing by the use of synthetic radioactive substances.

EXTERNAL RADIATION has the widest application in all branches of medicine because of its externally located sources of emission together with all the modifications. Radiation from a considerable distance (telegammapathy or far-focused therapy) is used in the case of deeply located malignant tumors. There are special installations created where radioactive cobalt is used and (to a lesser degree) radioactive cesium. Close-focus or contact therapy (application method) is used in the treatment of both the malignant and non-malignant tumors and also in the treatment of skin diseases. At the present time cobalt and phosphorus are used in the applicators of different forms.

The method of INTRACAVITARY RADIATION, for which cobalt and gold are mainly used, also has several modifications mainly regarding the forms and consistencies of the substances which are introduced into the natural cavities of the human body.

The INTERSTITIAL RADIATION consists of the introduction of radioactive matter (cobalt and gold) directly into the affected tissue. There are also several modification to this method depending on the consistency of the preparation (metallic acicular cobalt or gold in a colloidal state).

INTERNAL RADIATION. During the early periods of the development of medical radiology, the use of synthetic radioactive isotopes by means of oral or peroral introduction seemed very promising. Keeping in mind that the bone tissue absorbs phosphorus, calcium and strontium, we expected success in the curing of the sarcoma of the bone; and remembering that thyroid tissue absorbs iodine, we hoped to successfully cure cancer of the thyroid. However, the hopes bestowed on this therapeutic method as well as the idea of internal introduction of isotopes for diagnostic purposes were but little justified. At present the only practical value of the internal introduction of radioactive phosphorus has been in the cure of polycythemia. To some degree this method proved useful also in the metastases of the skeleton and the lymphatic system.

Thus, out of the four groups of methods, the most practical one is the method of external radiation. Each of the remaining is used mainly in the capacity of additional and auxiliary methods, both for the external

radiation therapy and especially for surgical methods of curing.

The contemporary stage of development of clinical radiology, as already stated, differs greatly from the preceeding. It is characterized by the following properties.

The number of isotopes which are used in medicine are considerably stabilized. The basic methods of diagnostics and therapy have been formulated; therefore, the number of new isotopes being tested and the number of new methods being developed have sharply decreased. All attention of scientific research and construction is directed toward the perfection of the already existing methods and radiological apparatus. The methods of external radiation are being perfected. It has been found that all forms of kinetic radiation are more effective that static; therefore, we are now developing these modifications for telegamma therapy and are constructing rotating telegamma apparatus.

The use of hard and super-hard rays turned out to be quite effective. They are generated by means of betatrons of various constructions and by linear accelerators from 4 to 35 MV (megavolts). The use of megavolt energy allows one to concentrate and evenly distribute the dosage on the tumors, sparing the healthy tissues and especially the skin.

Nuclear therapy can have special application with the aid of a cyclotron which gives a narrow beam of alpha particles with an energy close to a billion electrovolts. Nuclear therapy can be realized only in irradiation of small areas (about 1 cm^3) by a strictly localized beam, as for example in the irradiation of the hypophysis (radiological hypophysectomy in generalized cancer of the breast).

The methods of short-focus contact therapy of intracavitary and interstitial methods are also being perfected. The forms of radioactive preparations which are used in the intracavitary therapy are beginning to change. With the rectilinear preparations of cobalt they use also preparations in the form of beads of all sizes evenly distributed in a plastic mass (plastobalt). In macrosuspensions the beads of the plastobalt are weighed in a liquid media of different specific gravities depending on whether they distribute themselves evenly, sink, or float. The testing of these new forms of radioactive preparations in our institute showed their advantage over the old methods. We also use liquid preparations which are introduced into the cavities in baloons,

and new kinds of colloidal solutions of gold with different sizes of colloidal particles, etc. For the interstitial radiation besides sticking cobalt needles into the areas to be irradiated, the also sew it with hollow nylon thread inside of which there are pieces of thin cobalt wire.

It was suggested to use sewing of the swelling with nylon tapes or catgut saturated with radioactive phosphorus to facilitate interstitial radiation. It was also suggested to insert (by shooting) into the swelling by means of a special instrument (gun) some special non-removable needles of radioactive gold. Abroad they insert through the operative opening into the region of the hypophysis radioactive yttrium confined in thin-walled needles of stainless steel.

In the branch of internal radiation, the thought of the researchers took a special bent. They are trying to develop a substance of biological and tumorotropic nature which would lead the isotopes which are attached to it to the tumors. This idea is close to the idea of neutrontrapping therapy. This method utilizes the ability of some matters to travel from the blood to the different tissues with varying velocities. Since the tumorous tissue absorbs the different matter more quickly there occurred the idea to saturate the tumor with substances capable of creating in it induced radioactivity. For this purpose we are testing boron, litium and uranium. However, this path is still beset by many difficulties.

The second outstanding characteristic of the present period is the comparative study of the clinical data which was obtained by the application of the different diagnostic and therapeutic methods. Isolated results for the past five to ten years of observation make it possible even now to give a sober evaluation and to assign the corresponding place in clinical practice to each of the developed methods.

The third characteristic is the detailed study of the reactions of the organism to radiation in any form, the fight against this reaction and its prophylactics. The radiation clinic already possesses several very effective means of combating both the general reaction of the organism and the local reaction of the skin, mucous membranes, etc. Suffice it to name only a few such as: hemotransfusion, hormone reaction and medicaments such as mercamin, propanin, cystamin, capherid, etc. The use of all these diminishes the reaction to radiation, creates favorable conditions for radiation therapy, and increases its effectiveness.

The fourth characteristic is the study of the effect of radiation on the personnel which is working with the radioactive energy in medicine and the development of means for their protection. We should note here the development of the new dosemeters and protective devices. In the last three years in our institute alone they developed 18 protective constructions for work with radioactive isotopes, such as : screens, safes, containers syringes, radio-manipulated tables, etc. All of these are now in mass production.

The fifth and the last characteristic of the present period is, that during it, the science of radiology has been formulated and organized into a new of therapeutic and preventive establishments. Here belong the formation of X-ray and radiological departments, radiological groups at the first aid and epidemological stations, the development of different rules and directives, civilian norms, typical plans for radiological departments, etc, and the preparation of radiological divisions in all units.

Summarizing the development of radiology in the past 15 years, it is possible to map out several immediate prospects for its development.

In the coming years the scientific development of clinical radiology will continue in the following basic directions.

1) Perfection of the techniques of radiological methods of diagnostics in the field of circulatory and metabolic processes and also the diagnosis of the early forms of cancer. For this purpose our national industry will put out in the nearest future new kinds of radiodiagnostic apparatus (scanners, diascins) and special probes equipped with oscillating counting devices.

2) Perfection of the techniques of all forms of radiological therapy. The development of a rotating telegamma-apparatus is now about to be finished. Soon the beta-trons and linear accelerators will be installed. To improve the use of the methods of intracavitary and interstitial therapies there is planned a national production of sets of radiological instruments and apparatus for the utilization of macrosuspensions and beads. All this will allow a wide application of radioactive isotopes; it will enable us to cure the late stages of cancer and to remove the term "incurably ill".

3) Improvements in the protection of the personnel and the decrease of harmful effects of radiation on the patients. Our therapeutic and preventive institutions are already receiving sets of protective equipment in

accordance with the already developed schedule of delivery of this equipment to the radiological departments and faculties.

At the present time all efforts are being exerted in our country to create conditions for medical radiology to take its rightful place in medicine.

IONIZING RADIATION AND FETAL PROTECTION

-USSR-

[Following is the translation of an article by A. P. Kiryushchenkov in Sovetskaya meditsina (Soviet Medicine), Vol 24, No 9, Moscow, September 1960, pages 92-97.]

The study of the effects of X-ray and gamma rays on the prenatal development of organisms began several years after Roentgen discovered X-rays (1895) and Becquerel discovered natural radioactivity (1896).

The first research on the effect of ionizing radiation on the reproductive cells was conducted by I. R. Tarkhanov in 1896. He noticed that the eggs of lampreys which were subjected to X-rays ceased to reproduce. In 1901 there appeared the first announcement by Barr and Bulle concerning the unfortunate outcome of the pregnancy of a young woman after she had been X-rayed in the pelvic region.

Beginning in the twenties and thirties of the present century numerous observations were published on the outcome of pregnancies of women who were subjected to radiation at different stages of pregnancy. It was noticed that the exposure to radiation of the pelvic region of pregnant women often led to the death of the fetus. This observation made it possible for E. A. Arkhangel'skiy, A. Mayer, E. Ganzoni, H. Widmer and others to use X-rays as a means of interrupting pregnancies.

Many researchers were studying the anomalies of development of different organs and systems of children born to mothers who were exposed to radiation. L. F. Drissen, L. Zappert, D. P. Murphy, M. de Renyi, H. W. Jones and W. Neil brought together and systematized a greater part of the available information on frequency and kinds of deformity in children who were exposed to radiation in their pre-natal state. The frequency of

these anomalies had a wide oscillation: from 20 to 50 - 60 per cent. Among these anomalies the ones most often occurring were microcephalia and microphthalamia.

After the Second World War data was published on the outcome of pregnancies of women who were subjected to the explosion of atomic bombs in Hiroshima and Nagasaki. J. N. Iomazaki, S. W. Wright, P. M. Wright and G. W. Glummer stated that pregnant women who were in the radius of 1200 - 2000 meters from the hypocenter had involuntary abortions and stillbirths. The children who were born were found to have speech defects, microcephalic idiocy, cataracts and other anomalies of development.

Thus, the majority of the people studying the influence of ionizing rays on the fetus seem to agree that exposure to irradiation at the time of pregnancy constitutes a direct danger to the offspring. The exposure to radiation is more dangerous during the first half of pregnancy than during the second. The result of exposure to radiation can mean the death of the fetus or the birth of an offspring with different anomalies of development.

The clinical experiments on the high sensitivity of the human embryo to the effects of ionizing radiation were supported by the results of experiments on animals. This experimentation made it possible to establish several regular patterns in the relationships between the radioactive energy and embryogenesis. In 1908 S. G. Zaretskiy studied in detail the effect of X-rays on the ovaries and the course of pregnancy in animals. He maintained that the follicular apparatus of the ovaries has a high sensitivity to radioactivity. The exposure of the ovaries of the rabbit to radiation during the first days of pregnancy almost always results in intrauterine death of the embryo. This, the author explains, is the result of not only the injury to the ovaries but also the result of the direct effect of X-rays on the embryo itself.

G. F. Korsakova, P. G. Svetlov, E. G. Lomovskaya, Ye. I. Voroblova, L. B. Russel, W. L. Russel and others established a definite correlation between the degree of exposure to radiation, the stage of embryonic development and the sensitivity of the embryo to the effects of radiation. The experiments were conducted primarily on mice and rats and the degree of exposure at any single time varied from 25 to 400 r.

When the animals are exposed to radiation during the first periods of pregnancy (dosage 200 r.), we can

observe a high mortality in the intra-uterine embryos, however, those surviving were born with no apparent signs of damage due to radiation. The exposure to X-rays of the same intensity during the period of differentiation of organs and tissues of the embryo results in high frequency of abnormalities of development and a high mortality rate after birth. Exposure to radiation in the late period of gestation leads to the irradiation diseases in the offspring (strong hypotrophy, hemorrhages, leucopenia, and anemia).

The different outcomes of pregnancies which were observed in the experimental animals which received equal dosage of ionizing radiation depend upon the differences in the sensitivity of the embryo to the effects of radiation.

At the early stages of development the embryonic cells quickly undergo irreversible changes under the influence of penetrating rays. As a result of that the number of intrauterine deaths is high.

We notice that at the time of organogenesis there exists a process of selective injury to those organs and tissues which at the moment of exposure are in a state of heightened differentiation and metabolism. Most often radiation affects the nervous system and the eyes of the mebryo which points to the higher sensitivity of the ectoderm to radiation.

In the later stages of embryogenesis, in connection with the end of morphogenesis, the sensitivity of the embryo to radioactivity is considerably lower. Exposure to radiation in this period of prenatal development does not cause high mortality of the fetus; nor does it cause deformity. However, the offspring show the symptoms of irradiation disease.

Each organ (or system of organs) at certain times has a heightened sensitivity to radioactivity. At these times even a relatively low dose of radiation, not higher than 25 r., causes anomalies of development. These embryonic periods of greater sensitivity to radiation are called critical periods.

For diagnostic examinations the X-ray dose varies from 5 to 10 r. Therefore, such examinations of pregnant women at the critical period of embryonic development may have deleterious effects on the growth and formation of the fetus.

Which period of prenatal development of the human embryo is the most dangerous in respect to the appearance of damage by radiation?

P. G. Svetlov, L. E. Russel, and W. L. Russel think that from the second to seventh week of pregnancy is the danger period. The chances of damage to the human embryo here are highest. Therefore, when X-ray examination of the pelvic region of pregnant women during the early period of pregnancy is inevitable, the dosage should not exceed 1 r.

Numerous experiments and clinical observations showed that the disruptions of the embryonic development can be caused not only by the emission of radiation directly on the embryo but also indirectly by the changes which take plan in the organism of the mother.

N. A. Kalinina, A. D. Bukhavtsova, and others have shown in their experiments on pregnant animals exposed to radiation that the screening of the pregnant uterus during general X-ray exposure does not prevent the appearance of X-ray damage in the developing embryos. W. Flaskamp quotes a case where a patient in her second and third months of pregnancy was subjected to X-ray therapy as a result of cancer of the mammary gland. Three months after birth, the child was diagnosed as microcephalic with extensive damage to the eyes. H. Bailey, H. J. Bagg, Schulze-Berge and others describe similar cases.

The essence of the effects of indirect radiation is the fact that under the influence of radiation the metabolism of the mother's body is disrupted. These disruptions occur in the very important fermentative processes, the formation and circulation of blood, and permeability. Toxemia and autoinfection also develop. Changes in the placenta which are caused by exposure of pregnant women to radiation also have deleterious effects on the fetus (M. N. Kuznetsova).

All these changes in the mother's organism and in the placenta cause disruptions of the proper conditions for development of the fetus and increase the effects of direct ionizing radiation.

Because of high sensitivity of the fetus to radiation, it is necessary to develop effective means of protecting it. One of the forms of such protection against ionizing radiation is injection of anti-radiation chemical substances.

At the present time we know a great number of different chemical compounds which, when used prophylactiely, weaken the damage from radiation and speed up the process of recovery of damaged functions of the organism. Included in such compounds are substances which form methemoglobin (sodium cyanide, sodium azide, malononitril),

narcotic substances of central and peripheral action (diethyl ether, etho-barbamyl anaesthetic), sympathetic and parasympathetic substances (adrenalin, acetylcholine), hormones (estrogens, ACTH), sulphur-containing compounds (glutathione, thioures, unithiole, cysteine, cystamine, cysteamine), and several others.

All substances which have anti-radiation qualities possess certain properties in common. They are effective only if introduced before irradiation; in order to have an effective protective action you have to use large doses of the preparation. Lastly an essential precondition for the realization of chemical protection is the presence of oxygen in the immediate surroundings.

Of all such chemical protective substances the best known are the sulphur-containing compounds. Among the sulphur-contained compounds the most effective is cysteamin (a Soviet preparation called mercamin) and cystamin.

According to the data of V. P. Korotkova, H. Langendorf, R. Koch, H. Sauer, D. G. Doherty, W. T. Burnett, R. Shapira and others, mercamin is effective in preventing death in 48 - 100 per cent of the animals which were exposed to a lethal dose of X-rays.

The defensive chemical substances do not prevent irradiation illness however, but the animals do seem to show a quicker return to normal weight, a speeding up of regeneration of bone marrow, liver, spleen and the intestine.

It is interesting to note that the prophylactic introduction of mercamin has a positive effect on the regeneration of organs sensitive to radioactivity, but does not prevent the massive atresia of the follicles of animals which were exposed to a lethal dose of radiation (P. Desaive, Z. Bacq, A. Herve and J. van Lanker).

Mercamin has been used successfully both in the Soviet Union and abroad for the prophylactics and therapy of radiation illness in oncological patients who had been subjected to deep roentgen therapy. It was established that a human body can well take a 200 mg dose of mercamin introvenously. With such an introduction of mercamin the after-effects of radiation illness such as an upset of intestinal functions and leucopenia disappear. It is valuable that this preparation, while relieving the course of radiation illness, does not decrease the positive effect of roentgen rays on the growth of tumors (Z. Bacq).

The mechanism of chemical protection against radiation is a very complex and still not fully understood

process. The sulphur-containing substances exert an influence on the different pathogenic aspects of irradiation effects. As a result of the prophylactic injection of the chemical defense substances, the concentration of active water radicals is lowered, the conditions of hypoxia are created and a protection of SH-groups of enzymes and tissue proteins takes place.

Notwithstanding the positive results of the use of chemical anti-radiation protection in experimental and clinical conditions, these preparations so far have not been used for the protection of the fetus from ionizing radiation. At the same time the danger to the fetus is very great when the mother comes into contact with a source of radiation.

F. B. Shapiro announced that she had successfully used heroin as a means of protecting nine- and twelve-day embryos of mice which had been exposed to gamma- radiation Co^{60} in 200 r. As a result of this prophylactic use of heroin there was noted a decrease of intrauterine deaths and deaths after birth, a normalization of the processes of growth and a decrease of deformities.

R. Rugh, H. Gludstone, J. Maisin, H, Maisin, A. Dunjie, and P. Maldaque injected mercamin into pregnant mice and rats and then subjected them to X-rays in 300 to 700 r. dosages. In all cases the use of mercamin increased the rate of survival and normalization of the growth process of the offspring.

We were studying the effectiveness of mercamin in the radiation of rat embryos at the beginning of the organ-formation period (ninth day of development) and at its end (15th day). It was noted that its protective effectiveness is determined by the stage of embyonic development and the dose of radiation. At the beginning of the organ-formation period when the embryo as a result of active differentiation of organs and tissues has a high sensitivity to radiation, the prophylactic injection of mercamin has almost no effect (dose of radiation 300 r.). Decreasing the dose from 300 to 200 r. at the same period of ontogenesis resulted in a considerable increase of live births and a decrease of the number of anomalies in the new-born rats.

When mercamin is introduced at the end of the differentiation period, when the radio-sensitivity of the fetus is considerably lower, it increases the number of rats born alive (about two times) and decreases the death rate after birth. Besides increasing the survival level and decreasing the death rate, the injection of mercamin had a positive effect also on the progress of

of irradiation illness in the new-born (less loss of weight, absence of anemia, and a considerably faster recovery from leucopoiesis).

The mechanism of chemical protection of the fetus from the effects of ionizing radiation is virtually unstudied. The protection of the fetus depends to a high degree upon the ability, speed and degree of permeation of the protective substances through the placenta. We know that the placenta is a barrier which prevents many harmful and toxic substances in the mother's body from reaching the fetus.

V. I. Bodyashina and A. P. Kiryushchenkov studied the permeation of S^{35} mercamin through the placenta of a rat and its distribution in the organs of the mother and the fetus. As a result of the shielding quality of the placenta, the amount of marked sulphur in the mercamin was three to five times less in the organs of the fetus than in the mother's organs.

The permeation of protective substances from the mother to the fetus allows us to suppose that with the help of sulphur-containing compounds, it will be possible to create an immediate protection of the embryos from the direct action of penetrating rays because at that moment, the protective agent is already in the tissues of the fetus. A decrease of anomalies of development of the central nervous system of rats born from mothers treated by mercamin also points to the possibility of such a mechanism. From the data of S. P. Hicks, we know that the changes in the central nervous system of the rat's embryos under the influence of radiation take place very quickly; sometimes it is a question of several hours. Therefore, L. B. Russel thinks that these changes can only be caused by direct irradiation on the embryo, because during such a short period of time, the radiation illness in the mother's body does not have time to develop.

The sulphur-containing compounds seem to have a double effect. They not only cause an immediate protection of the fetus but also seem to have an indirect effect on the development of the irradiated embryo. An easier recovery from the radiation illness of the mother which is observed after the prophylactic injection of the chemical protectors supports this observation.

Thus, one of the most important problems of radioactivity, the protection of the fetus from the effects of ionizing radiation, has begun to develop successfully. At the present time we have proved by experimental methods that it is theoretically possible

to protect the fetus from irradition damage by the prophylactic injection of chemical protective compounds.

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